**Small Business Innovation Research/Small Business Tech Transfer**

# Habitat ISHM Using Non-Invasive Load Management Analytics, Phase I

Completed Technology Project (2018 - 2019)

## Project Introduction

We believe a robust approach to integrated system health management (ISHM) design is the application of redundancy. Redundancy is often thought of in terms of hardware; however, functional, analytic, and information redundancy strategies should also be considered.
Modeling sensor information is invaluable for diagnostics and critical path analysis. A total system approach is an efficient means of prognostics as well as identifying the time of failure. However, fidelity and resolution must be considered in both approaches. There are compounding errors as the subsystems are aggregated in a component model. Sensors themselves introduce a point of error and require due consideration of size, weight, and power (SWaP).

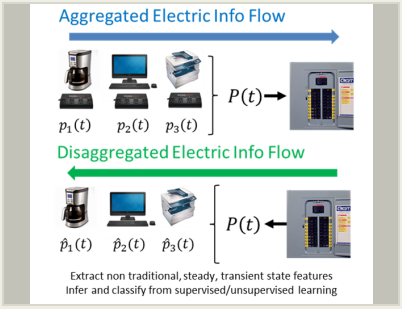
Signal processing, machine learning, and data mining techniques are common approaches in ISHM to improve the accuracy of alerts for known issues and an ability to identify latent and unknown failure conditions. Such techniques are not limited to ISHM. They are also used in fraud detection, image processing, medical diagnostics, and other domains.

Our innovation draws from the domain of electrical power systems with the application of non-invasive load management (NILM) models for load disaggregation. NILM is a means of extracting and analyzing discrete end-use system components from an aggregate energy signal. NILM evolution has run parallel with the developments in signal processing, machine learning, and data mining for feature extraction, classification, and action. A NILM approach for managing habitat subsystems allows for optimization of the number of sensors, mitigating points of information failure and the constraints of size, weight, and power while providing analytical redundancy to hardware systems. We submit that the application of disaggregation analytics is an innovative ISHM technology that supports NASA missions.

## Anticipated Benefits

When NILM algorithms reside on a SSE device, the device becomes a component "smart sensor". The reduction in the number of sensors mitigates sensory overload and aids in alarm management without compromising the crew's ability to respond to emergencies. The use of NILM analytics and smart sensors is not limited to spaceflight or extra-terrestrial operations. The methodology can be applied in building management systems for facilities to reduce cost of operations.

There are a limited number of NILM disaggregation applications and none that integrate ISHM as a feature. NILM tools, in conjunction with smart meters, could provide information to improve equipment design, building simulation, and construction, utility operations, and policy decisions. These would benefit residential and commercial consumers with greater efficiencies and lower costs. A reduction of only 0.01% would have yielded $3.2BM in savings in



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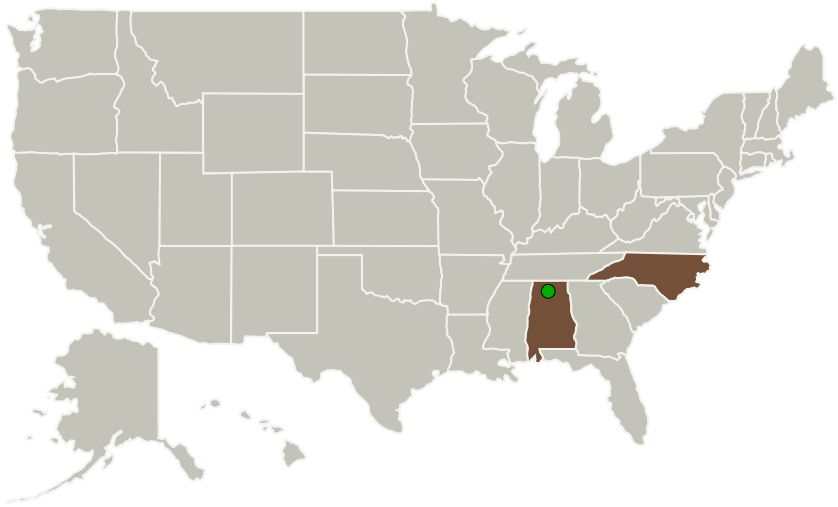
2016 (Energy Information Administration data).

### Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| MHI Energy Information Solutions | Lead Organization | Industry | Durham, North Carolina |
| Marshall Space Flight Center(MSFC) | Supporting Organization | NASA Center | Huntsville, Alabama |

| Primary U.S. Work Locations | |
|---|---|
| Alabama | North Carolina |

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

MHI Energy Information Solutions

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

**Program Director:**

Jason L Kessler

**Program Manager:**

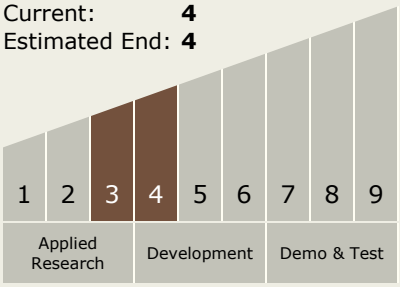
Carlos Torrez

**Principal Investigator:**

Michael Chevalier

## Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



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## Project Transitions

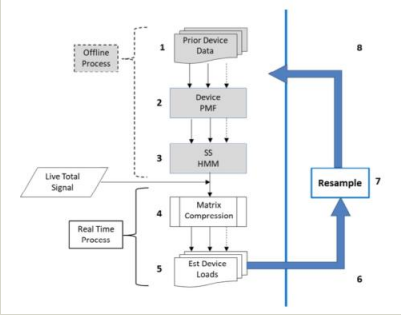
**July 2018:** Project Start

**February 2019:** Closed out

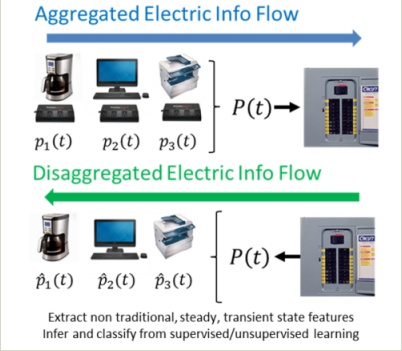
**Closeout Documentation:**

- Final Summary Chart*(https://techport.nasa.gov/file/141351)*

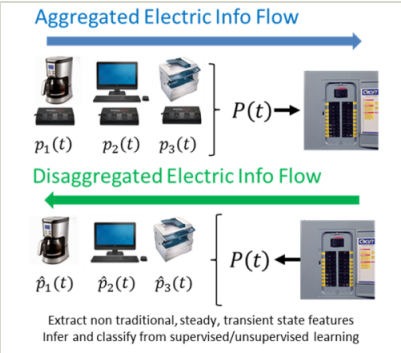
## Images




**Final Summary Chart Image**
Habitat ISHM Using Non-Invasive Load Management Analytics, Phase I
*(https://techport.nasa.gov/image/134272)*




**Final Summary Chart Image**
Habitat ISHM Using Non-Invasive Load Management Analytics, Phase I
*(https://techport.nasa.gov/image/127534)*




**Project Image**
Habitat ISHM Using Non-Invasive Load Management Analytics, Phase I
*(https://techport.nasa.gov/image/128385)*

## Technology Areas

**Primary:**

- TX03 Aerospace Power and Energy Storage
  - TX03.3 Power Management and Distribution
    - TX03.3.3 Electrical Power Conversion and Regulation

## Target Destinations

Earth, The Moon, Mars